Economics of Site Preparation and Release Treatments Using Herbicides in Central Georgia

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ABSTRACT. *Land expectation values (LEV) of site preparation and release treatments using herbicides in central Georgia are calculated and compared. Loblolly pine growth and hardwood competition levels were measured at age 6 for the site preparation treatments and age 8 for the release treatments. These measurements were projected to final harvest using the North Carolina State University growth and yield simulator. On six directly comparable sites, site preparation improved land expectation values more than release. When the most profitable treatments on each site were compared, site preparation LEVs (after tax) were more than twice as profitable as release ($403 vs. $188/ac). Velpar L[1] and Pronone 10G herbicide treatments increased the land expectation value most for site preparation. Arsenal AC and Velpar L provided the highest returns among the herbicides tested for release. South. J. Appl. For. 22(3):156–162.*

Demands for southern timber are growing as both domestic and international economies continue to grow. Pressure is also being placed on southern timber resources by the reduction in harvest levels from public lands in the Pacific Northwest. As a result, softwood timber removals are now exceeding growth. For the first time since 1952, southern softwood inventories declined from 1987 to 1992 (Powell et al. 1993). Given the decline in softwood inventories, there is a growing concern whether or not the South can continue to provide for additional softwood harvests to meet future demands.

One way to meet increasing demands is to take advantage of economical opportunities for intensive management. Intensive site preparation and release treatments, using herbicides, are increasingly being used to help managers do a better reforestation job (Minogue et al. 1991). Treatments improve the growth of crop trees as competition for light, water, and minerals is decreased (Walstad and Kuch 1987). However, investments in intensive site preparation and release treatments are expensive, which raises crucial questions. Should forestland managers expend limited investment dollars for such treatments? Which regeneration system is more suitable economically for the industrial or nonindustrial private forest (NIPF) landowner? Which herbicide treatments are most profitable? Partial answers are provided in this article by assessing the comparative economic effectiveness of several labeled forestry herbicides for site preparation and release treatments on loblolly pine (*Pinus taeda* L.) stands.

Methods

Biological Data

Four herbicide treatments for forest site preparation and four herbicide treatments for release were compared in central Georgia, from a study established in 1984, to determine the growth response of loblolly pine (Miller and Edwards 1995). Site preparation plots were measured at age 6, and release plots were measured at age 8 from three comparable locations. Herbicides used for site preparation included Pronone 10G (hexazinone), Roundup (glyphosate), Velpar L (hexazinone) and Garlon 4 (triclopyr ester). Herbicides used for release included Pronone 10G, Roundup, Velpar L, and Arsenal AC (imazapyr). Pronone 10G is a granule; the other herbicides are dissolved in water and applied as sprays. All sites had been harvested for fuelwood, taking all trees 4 in. in diameter and larger. Site index estimates were derived from onsite soil series determinations and the Natural Resource

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[1] Use of trade names is for the reader's information and convenience. Use in these studies does not constitute official endorsement or approval by the U.S. Department of Agriculture to the exclusion of any other suitable product.

Table 1. Location, site, and soil characteristics for sites used to compare site preparation and release of loblolly pine in central Georgia.

Tract	County	Province	Site index[a] (ft)	Soil and slope
Site preparation sites				
Ellington	Laurens	Coastal Plain Sandhills	70	Ailey loamy sand, 8–17% slope, and Orangeburg loamy sand, 12–17% slope.
McElroy	Monroe	Piedmont	75	Gwinnett sandy clay loam, 6–15% slope, eroded.
Grimsley	Twiggs	Coastal Plain	85	Tifton fine sandy loam, 2–5% slope and Norfolk loamy sand, 2–5% slope.
Release sites				
Patton	Twiggs	Coastal Plain	70	Ailey loamy sand, 8–17% slope.
Robinson	Monroe	Piedmont	75	Gwinnett sandy clay loam, 6–15% slope, eroded.
Duggins	Laurens	Coastal Plain Sandhills	85	Cowarts loamy sand, 2–5% slope, Fuquay loamy sand, 0–5% slope, Lucy loamy sand, 0–5% slope, and Orangeburg sandy loam, 5–8% slope, eroded.

[a] Base age 50, with values for loblolly pine derived from onsite soil series identification and the Natural Resources Conservation Service database.

Conservation Service database. Basic data on the province, site index (base age 50), soil, and slope description of each site are shown in Table 1.

Plots ranged in size from 0.5 to 2 ac. Comparisons were made between untreated check and herbicide treated plots. Measurements of pine and hardwood basal area (ft^2/ac), and number of trees surviving were taken for each plot (Tables 2 and 3).

Growth responses at age 6 and age 8, for site preparation and release treatments, respectively, are not old enough to make useful judgments of the economic merits of either treatment. Therefore, data were projected to final harvest using Version 3.2 of the North Carolina State University Loblolly Pine Growth and Yield Simulator (Smith and Hafley 1987). Required inputs for the model include: (1) site index (base age 50), (2) number of trees per acre, (3) pine basal area, (4) hardwood basal area, and (5) province of the site. Outputs from the model are the volumes of pine and hardwood sawtimber (bd ft Scribner), chip-n-saw (cords), and pulpwood (cords).

Management Regimes

The site-preparation management regime included: (1) herbicide site preparation and burning, (2) planting 726 trees/ac, (3) commercial thinning at age 15 and 20 to a basal area of 70 ft^2/ac, if the stand had at least 90 ft^2/ac of pine basal area present on the site, and (4) final harvesting at age 25, 30, 35, or 40, depending on which rotation length yielded the highest land expectation value (LEV). The release management regime includes: (1) burning the site to prepare for planting,

Table 2. Age 6 surviving trees, loblolly pine and hardwood basal area for site preparation sites in central Georgia.

Tract	Site index[a] (ft)	Herbicide treatment	Surviving trees (no./ac)	Pine basal area	Hardwood basal area
				(ft^2/ac)	
Ellington	70	Check	494	4.5	29.2
		Roundup[b]	581	12.8	8.4
		Velpar L	610	24.1	2.9
		Pronone 10G	624	19.7	6.2
		Garlon 4	421	5.5	5.1
McElroy	75	Check	595	5.0	7.0
		Roundup[b]	639	19.3	5.4
		Velpar L	610	13.7	2.5
		Pronone 10G	668	21.6	0.0
		Garlon 4	610	10.4	3.3
Grimsley	85	Check	581	3.8	10.6
		Roundup[b]	610	22.6	6.3
		Velpar L	595	35.9	2.5
		Pronone 10G	581	23.3	2.5
		Garlon 4	610	20.0	2.1

[a] Base age 50, with values derived for loblolly pine from onsite soil series identification and the Natural Resources Conservation Service database.
[b] Accord is now used instead of Roundup.

Table 3. Age 8 surviving trees, loblolly pine basal area and hardwood basal area for release sites in central Georgia.

Tract	Site index[a] (ft)	Herbicide treatment	Surviving trees (no./ac)[a]	Pine basal area	Hardwood basal area
				(ft^2/ac)	
Patton	70	Check	653	4.2	18.1
		Roundup[b]	552	15.5	13.5
		Velpar L	603	11.0	8.6
		Pronone 10G	595	8.2	20.1
		Arsenal AC	661	29.7	2.3
Robinson	75	Check	588	24.6	12.0
		Roundup[b]	566	31.9	5.6
		Velpar L	283	27.5	3.5
		Pronone 10G	385	20.4	7.2
		Arsenal AC	697	37.7	10.7
Duggins	85	Check	595	23.7	19.8
		Roundup[b]	595	18.3	15.2
		Velpar L	457	29.4	7.7
		Pronone 10G	530	33.5	13.9
		Arsenal AC	668	30.6	2.9

[a] Base age 50, with values derived for loblolly pine from onsite soil series identification and the Natural Resources Conservation Service database.
[b] Accord is now used instead of Roundup.

(2) planting 726 trees/ac on fuelwood harvested sites, (3) herbicide release in the third growing season, (4) commercial thinning at age 15 and 20 to a basal area of 70 ft^2/ac, if the stand had at least 90 ft^2/ac of pine basal area present on the site, and (5) final harvesting at age 25, 30, 35, or 40 depending on which rotation length was most beneficial. Management regimes for the check tracts are similar, except no herbicide treatments are performed.

Economics and Tax Assumptions

Current stumpage and product price data for Georgia were obtained from Timber-Mart South (1993–1997). Prices were averaged for 1993 through the first quarter of 1997 to eliminate cyclical peaks and valleys in prices. Product prices, rounded to the nearest dollar and adjusted to 1997 dollars, were: (1) pine sawtimber, $298/mbf, Scribner, (2) pine chip-n-saw, $80/cord, (3) pine pulpwood, $34/cord, and (4) hardwood pulpwood $16/cord. Prices were assumed to grow in real (after inflation) terms at a rate of 2%/yr in the next 15 yr; thereafter, prices were assumed to remain constant in real terms. These are conservative assumptions given the large increase in sawtimber stumpage prices forecast by Hayes and Adams (1992).

Costs for all site preparation and release treatments examined are presented in Tables 4 and 5, respectively. Application costs using tractor-mounted systems were assumed to be $27/ac for all treatments.

Planting and seedling costs were set at $61/ac, which included planting cost of $39/ac reported by Dubois et al. (1997) and an allowance for the purchase of seedlings. In addition, costs to prepare timber sales and to manage the stands was set at 10% of harvest value. Miscellaneous management costs of $1.30 ac/yr were assumed. All costs were expected to remain constant in real terms.

Tax rates vary by a number of factors including: income, number of dependents, other deductions, filing status (e.g., individual, corporate), location, and many other variables. This paper assumes a typical tax situation for landowners in Georgia. The assumed marginal federal and state income tax rate are 28 and 6%, respectively. Landowners in Georgia must also pay a

Table 4. Per acre herbicide site preparation treatment rates and herbicide costs in central Georgia, 1997.

Tract	Site index[a] (ft)	Herbicide	Treatment rate (amount/ac)	Herbicide cost ($/ac)
Ellington	70	Check	None	0.00
		Roundup[b]	1 gal	44.00
		Velpar L[c]	1.5 gal	66.75
		Pronone 10G[c]	30 lb	82.50
		Garlon 4	1 gal	64.50
McElroy	75	Check	None	0.00
		Roundup[b]	1 gal	44.00
		Velpar L[c]	1.75 gal	77.90
		Pronone 10G[c]	35 lb	96.25
		Garlon 4	1 gal	64.50
Grimsley	85	Check	None	0.00
		Roundup[b]	1 gal	44.00
		Velpar L[c]	1.25 gal	55.60
		Pronone 10G[c]	25 lb	68.75
		Garlon 4	1 gal	64.50

[a] Base age 50, with values derived for loblolly pine from onsite soil series identification and the Natural Resources Conservation Service database.
[b] The cost of Accord, the Roundup replacement, was used in the analysis.
[c] Velpar L and Pronone 10G were prescribed according to soil texture and organic matter per label guidelines.

Table 5. Per acre herbicide release treatment rates and herbicide costs in central Georgia, 1997.

Tract	Site index[a] (ft)	Herbicide	Treatment rate (amount/ac)	Herbicide cost ($/ac)
Patton	70	Check	None	0.00
		Roundup[b]	2 qt	22.00
		Velpar L[c]	2 qt	22.25
		Pronone 10G[c]	9 lb	24.75
		Arsenal AC[d]	32 oz	105.60
Robinson	75	Check	None	0.00
		Roundup[b]	2 qt	22.00
		Velpar L[c]	4.5 qt	50.10
		Pronone 10G[c]	15 lb	41.25
		Arsenal AC[d]	32 oz	105.60
Duggins	85	Check	None	0.00
		Roundup[b]	2 qt	22.00
		Velpar L[c]	2.5 qt	27.80
		Pronone 10G[c]	9 lb	24.75
		Arsenal AC[d]	32 oz	105.60

[a] Base age 50, with values for loblolly pine derived from onsite soil series identification and the Soil Conservation Service database.
[b] The cost of Accord, the Roundup replacement, was used in the analysis.
[c] Velpar L and Pronone 10G were prescribed according to soil texture and organic matter per label guidelines.
[d] Applied at labeled rate for time of study.

harvest tax of 2.5% levied on all sales. Property taxes are assumed to be $1.70 ac/yr. It was also assumed that landowners are eligible and elect to take the 10% investment tax credit and amortization over 8 tax years of onsite preparation and planting expenses. Release expenses are assumed to be done for timber stand improvement, not afforestation, therefore they were expensed immediately in this analysis.

Evaluation Criterion

Both before-tax and after-tax land expectation values (LEVs) were calculated for all scenarios to help analyze the returns from investing in site preparation or release treatments. LEV is calculated by finding the net future value of all revenues and costs at the stand rotation age (r) and finding the present value of an infinite series of similar managed rotations. Land expectation value is the value of bare land used for growing perpetual rotations of even-aged crops of trees. Revenues come from product harvests as the stand is thinned or clearcut. Costs are incurred when the site is brought into production, plus annual costs for fire protection and miscellaneous items. A simplified formula for LEV is:

$$LEV = \frac{\sum_{t=0}^{r} R_t(1+i)^{r-t} - \sum_{t=0}^{r} C_t(1+i)^{r-t}}{(1+i)^r - 1} \qquad (1)$$

where

LEV = land expectation value,

R_t = revenue occurring at year t,

C_t = cost occurring at year t,

r = rotation age, in years, and

i = discount rate, per year expressed as a decimal.

The rate used to discount the future cash flows is the real discount rate. Inflation is factored out of the analysis by reporting all cash flows in real terms. A comparison between nominal interest rates (with inflation) and real interest rates (without inflation) can be made. For example, if the real discount rate is 7% and the expected inflation is 4% per year, the nominal discount rate would be approximately 11% [(1.04) * (1.07) – 1]. Proper use of either the real or nominal discount rates will lead to the same answer, therefore only the real discount rate is used.

Change in LEV is the key criterion used to evaluate investment in site preparation and release treatments. Change in LEV is the difference between the treatment LEV and the check LEV.

Results and Discussion

Results show that herbicide site preparation and release treatments have a significant impact on anticipated returns. The average land expectation values increased for the majority of herbicide site preparation and release treatments, assuming interest rates of 3 to 7% are used to discount future cash flows. The returns are not uniform, however. Type of treatment and site quality seem to be important factors in predicting improvement in land expectation values. In addition, some herbicides produced higher returns than others.

Site Preparation

Both before- and after-tax land expectation values for check and herbicide treatments for site prepared tracts are shown in Table 6, using a 4% real discount rate. The Ellington tract had the lowest check and treated LEVs. These low returns came on the lowest quality lands (site index 70, base age 50) where the pine crop at age six did not dominate the site due to hardwood competition (Table 2). The before-tax LEVs improved as site index increased. The check and average treated LEV on the lowest site quality site (Ellington) were $91/ac and $511/ac, respectively. In contrast, the check and average treated LEV on the highest quality site (Grimsley) were $359/ac and $1,189/ac, respectively.

Including taxes did not change the ranking of the returns. After-tax LEVs also improved as site index increased. The check and average treated LEV on the lowest site quality site (Ellington) were $29/ac and $298/ac, respectively. In contrast, the check and average treated LEV on the highest quality site (Grimsley) were $202/ac and $733/ac, respectively.

Herbicide site preparation proved to be worthwhile since treatments improved LEVs on all sites reported on using the 4% discount rate and measured both before and after taxes (Table 6). The concentration of growth in the high valued pine crop more than paid for the additional investment in site preparation. On average, herbicide site preparation on these

Table 6. Before-tax and after-tax land expectation values (LEVs) for site preparation tracts in central Georgia assuming a 4% real discount rate.

Tract	Site index[a] (ft)	Herbicide	Before-tax		After-tax	
			LEV	Change in LEV	LEV	Change in LEV
			($/ac)			
Ellington	70	Check	91	—	29	—
		Roundup[b]	493	402	287	258
		Velpar L	671	580	401	372
		Pronone 10G	573	482	338	309
		Garlon 4	307	216	167	138
Average treated			511	420	298	269
McElroy	75	Check	384	—	217	—
		Roundup[b]	640	256	381	164
		Velpar L	654	270	390	173
		Pronone 10G	715	331	429	212
		Garlon 4	615	231	365	148
Average treated			656	272	391	174
Grimsley	85	Check	359	—	202	—
		Roundup[b]	1,100	741	677	475
		Velpar L	1,333	974	826	624
		Pronone 10G	1,162	803	716	514
		Garlon 4	1,159	800	714	512
Average treated			1,189	830	733	531

[a] Base age 50, with values for loblolly pine derived from onsite soil series identification and the Natural Resources Conservation Service database.
[b] The cost of Accord, the Roundup replacement, was used in the analysis.

sites increased the LEV by $272 to $830/ac before taxes and $174 to $531/ac after taxes.

The ranking of the average individual herbicide site preparation results was consistent. The best before-tax improvements in LEV came from Velpar L ($608/ac), Pronone 10G ($539/ac), and Roundup ($466/ac), and finally, Garlon 4 ($416/ac). The rankings of the after- tax improvements in LEV were the same with Velpar L ($390/ac), Pronone 10G ($345/ac), Roundup ($299/ac), and finally, Garlon 4 ($267/ac). Varying the discount rate from 3% to 7% did not change these rankings (Figure 1).

Release

Both before-tax and after-tax LEVs for check and herbicide released tracts are shown in Table 7. Overall, the results indicate that site quality and LEV levels are related. The lower the quality of the site, the lower the average LEV; the higher the quality of the site, the higher the average LEV.

Four release treatments failed to improve the LEV, assuming a 4% discount rate: (1) the Pronone 10G treatment on the Patton tract, (2) the Pronone 10G and the Arsenal AC treatments on the Robinson tract, and (3) the Roundup treatment on the Duggins tracts (Table 7). Hardwood competition was comparatively lower on the Robinson Check relative to the two other check plots. Therefore, improvements in the LEV were more difficult for the treated stands. The largest improvement in LEV occurred on the Patton tract with an average improvement from treatment of $257/ac (before taxes); the smallest improvement in LEV occurred in the Robinson tract with an average before-tax loss of $9/ac. Release on the Duggins tract improved the LEV by $169/ac. Thus, on average, the largest improvement in LEVs was found on the lowest site index, where the untreated check trees grew poorly.

The largest improvement in before-tax LEV came on the Arsenal AC ($228/ac) treatments. The application did cause some initial pine damage, but the intensive investment was justified, on average, based on its economic performance. Note that the Arsenal AC results were obtained using an application rate of 32 oz/ac instead of the currently labeled maximum treatment rate of 16 oz/ac. It is not known what the precise economic implications of the lower labeled rates are. However, Quicke et al. (1996) reported that release treatments in Arkansas using Arsenal at 32 oz/ac only increased loblolly pine volume by 9% compared to the volume produced on the 16 oz/ac treatments, after 2 growing seasons. Since herbicide costs are double at the 32 oz/ac rate, this poor additional physical response, compared to the 16 oz/ac rate, may not be enough to pay for the additional herbicide costs. The implication is that the net economic returns from the current maximum labeled rate may be higher than the higher dose treatment. That is important for the results reported here implying that reported returns are conservative.

Velpar L had the next best performance, yielding an improvement in before-tax LEV at $190/ac. The least improvements in before-tax LEVs came from the Roundup ($91/ac) and Pronone 10G ($47/ac), again assuming a 4% discount rate. Relative ranking of these results did not vary when taxes were added to the analysis and the discount rate was varied (Figure 1). However, low discount rates tend to

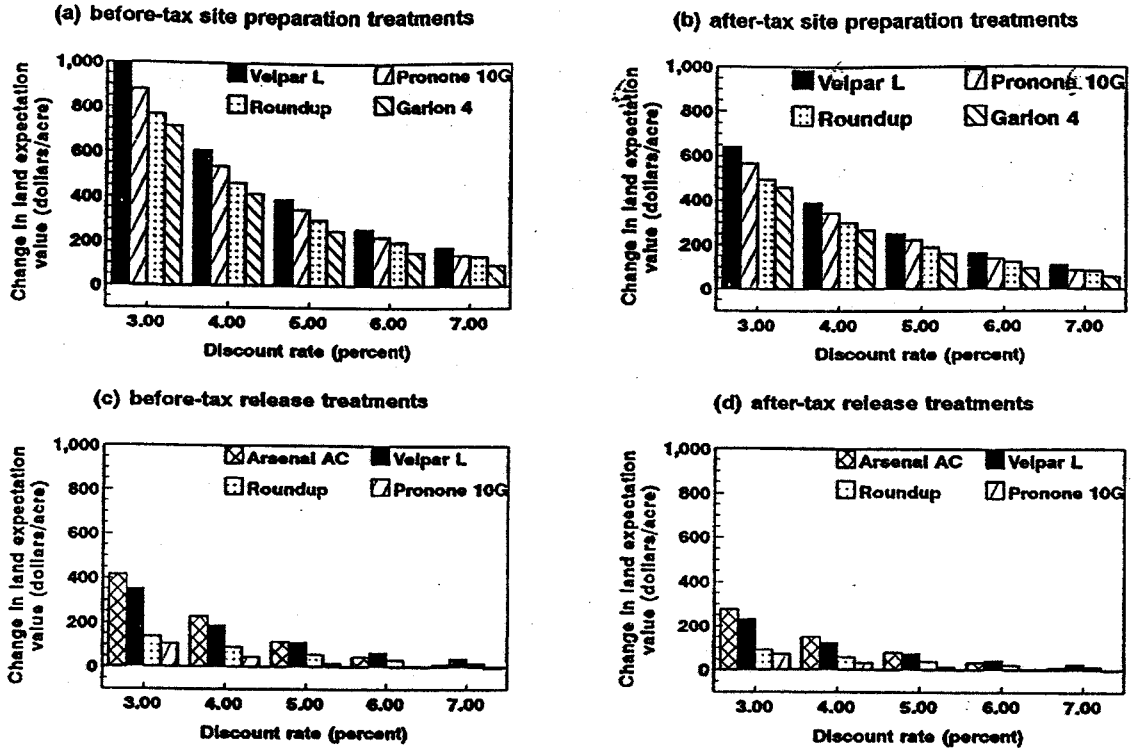

Figure 1. Comparison of the change in land expectation values for (a) before-tax site preparation treatments, (b) after-tax site preparation treatments, (c) before-tax release treatments, and (d) after-tax release treatments, for loblolly pine in central Georgia.

Table 7. Before-tax and after-tax land expectation values (LEVs) for release tracts in central Georgia assuming a 4% real discount rate.

Tract	Site index[a] (ft)	Herbicide	Before-tax		After-tax	
			LEV	Change in LEV	LEV	Change in LEV
			($/ac)			
Patton	70	Check	42	—	–2	—
		Roundup[b]	296	254	163	165
		Velpar L	295	253	162	164
		Pronone 10G	25	–17	–11	–9
		Arsenal AC[c]	578	536	348	350
Average treated			299	257	166	168
Robinson	75	Check	677	—	405	—
		Roundup[b]	746	69	452	47
		Velpar L	734	57	445	40
		Pronone 10G	609	–68	365	–40
		Arsenal AC[c]	583	–94	351	–54
Average treated			668	–9	403	–2
Duggins	85	Check	785	—	475	—
		Roundup[b]	734	–51	444	–31
		Velpar L	1,045	260	643	168
		Pronone 10G	1,010	225	621	146
		Arsenal AC[c]	1,025	240	634	159
Average treated			954	169	586	111

[a] Base age 50, with values derived for loblolly pine from onsite soil series identification and the Natural Resources Conservation Service database.
[b] The cost of Accord, the Roundup replacement, was used in the analysis.
[c] When the study was installed, the application rate of Arsenal AC was not set. Experimentally, 32 oz/ac of Arsenal AC were applied in the study but the current maximum labeled rate is 16 oz/ac.

magnify the differences among the herbicides; high discount rates then to mask the differences among the herbicides.

Site Preparation Versus Release

The three site preparation and the three release treatments were located on similar tracts, which facilitates a comparison of site preparation and release treatments. The Ellington and Patton, McElroy and Robinson, and Grimsley and Duggins tracts are on site index 70, 75, and 85 (base age 50) lands, respectively.

On these sites, using the 4% discount rate, the average site preparation treatment had an after-tax LEV of $474/ac; the average release treatment had an after-tax LEV of $385/ac. The results did vary by site quality. On the lowest quality lands examined, the average after-tax LEV on the site prepared tract was $298/ac (Ellington tract), whereas the lowest quality release tract had an after-tax LEV of $166/ac (Patton tract). On the highest quality lands examined, the Grimsley site prepared tract had a LEV of $733/ac, whereas the similar quality, Duggins released tract had a LEV of $586/ac.

Site preparation had an economic advantage over release investments in this study. Site preparation, while costlier than release, returned more in terms of increased before- and after-tax LEV than release. When the most profitable treatments for each site were compared, site preparation LEVs were on average more than twice as profitable as release ($403 vs $188/ac).

The potential for enhancing early pine growth is greatest in years 1 and 2 (Bacon and Zedaker 1987)—the time when woody plant control is at a maximum with site preparation treatments. This window of opportunity is lost with release treatments. Also, site preparation treatments offer possible residual control of herbaceous plants, or herbaceous weed control can be applied as a supplement to site preparation. Early pine mortality often occurs in year 1 through 3, which can be reduced with site preparation treatments, thus safeguarding stand stocking levels.

Ground application options with tractor-mounted systems are more viable with site preparation treatments, especially after a complete harvest as studied here, than during release treatments. Further, noxious weed infestations are best controlled at time of site preparation. The cost, choice of herbicides, and application difficulty to control noxious weeds increases after planting.

Conclusion

Both site preparation and release management strategies are profitable and increased landowner wealth. The rankings of the site preparation treatments were: (1) Velpar L, (2) Pronone 10G, (3) Roundup, and finally, (4) Garlon 4. The release treatments found Arsenal AC and Velpar L as more profitable than Roundup and Pronone 10G. These results are stable given differing assumptions about taxes and discount rates. On comparable treatment areas and using the same herbicides, site preparation provided larger increases in LEV than release treatments.

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